dustrial fatigue, having regard both to industrial efficiency and to the preservation of health among the workers." Grants are made to aid researches undertaken by independent bodies and also to individual students in research work; in making them the council has been guided by its knowledge of the quality of the research work undertaken by the professor or head of the department who recommends the student.

In referring on a previous occasion to the work of this new department we expressed the hope that though it was primarily established to encourage the application of scientific research to industrial methods, it might become the rallying point of other scientific branches subsidized by the government, eventually developing into an independent Ministry of Science. These hopes have been realized to a considerable extent, and we find no evidence that the department is regarded as a temporary expedient. Indeed, another step forward has been taken which we hardly dared to anticipate. The annual report of the department contains a series of paragraphs relating to the development of the organization of research in the Overseas Dominions. The home department has been in close touch with the Canadian Honorary Advisory Council for Scientific and Industrial Research, which was incorporated by a Canadian Act of Parliament a year ago. This Canadian council has promoted many valuable researches and inquiries, some of which have already produced important results. Again, in Australia, an Advisory Council of Science and Industry has been established, and has started a number of investigations which have aroused the active interest of manufacturers and others likely to benefit by the systematic application of science to industry. The New Zealand government took initial steps to organize scientific and industrial research as long ago as 1916, but the matter does not there seem to have passed beyond the stage of discussion. In South Africa there is an Industries Advisory Board, which deals not only with scientific and industrial research, but also with statistics of production, factory legislation, the encouragement of industries, and the development of natural resources. Finally, it is the intention of the government of India to establish after the war an Industrial Board and Department, which will succeed the Indian Munitions Board and extend its sphere of operations. As the chairman of that board has pointed out, munitions for a modern army cover practically all the wants of the civil community. It is also to be noted that a National Research Council was established in the United States of America in 1916, under the auspices of the National Academy of Sciences, and largely through the initiative of its president, Dr. Welch, and of Professor Hale. This council, as we have shown on previous occasions, did much valuable preparatory work before America entered the war, and since then it has so grown in usefulness and power that President Wilson has issued an executive order putting it upon a permanent basis.

The letter in which the Lord President, Lord Curzon of Kedleston, presents the report of the British Advisory Council to the King in Council, concludes as follows: "The foundations of a national system of scientific research are being truly laid. In the final structure as they (the Advisory Council) are planning it, the universities and technical colleges, the learned societies and the industries will be found taking their due place; not in subordination to the state, as our enemies like to see them, but working together for the common good in helpful cooperation."

SPECIAL ARTICLES

THE RELATION OF THE SECTOR OPENING OF THE SECTOR PHOTOMETER TO THE EXTINCTION COEFFICIENT

IN determining absorptions with a spectrograph and sector photometer it is necessary to know the relation existing between the sector opening and the extinction coefficient. If the two beams whose intensities are to be equalized by interposed sectors be donated by I and I' respectively, then

$$\log \frac{I}{I'} = e$$

defines e as the extinction coefficient of the

substance for which I' is the transmitted beam and I the corresponding incident beam. If these two beams, I and I', be equalized photographically by means of interposed rotating sectors, S and S', then some relation exists between I/I' and S'/S.

A previous determination by H. E. Howe[1] of this relation made

$$\frac{I}{I'} = \frac{S'}{S}$$

where S is the variable sector cutting down the beam I till it balances the beam I'. The equality was established by measuring with a sector photometer the transmissions of neutral smoke-glass plates, the transmissions of which had previously been measured on a visual spectrophotometer.

In further establishing the validity of this equality the method here employed has been to use likewise two beams of known relative intensities determined geometrically as a function of the relative distances of their sources from the slit of the spectrograph.

Using the Hilger quartz spectrograph, size *C*, in front of one half of a slit 3 mm. long there was placed a total reflecting prism whose face was illuminated through a variable sector by a fixed Nernst lamp. The illumination of the other half of the slit was accomplished by another Nernst lamp arranged on a runway in the axis of the collimator so that its distance from the slit could be varied at will.

The lamps were on the same 110-volt alternating current, city circuit, and plates were always made under such conditions that the voltage did not vary more than two volts during the course of an experiment. The lamps being of the same construction it seemed reasonable to suppose that the simultaneous variations in candle power of the two lamps due to such slight variations in voltage would be equivalent.

[1] H. E. Howe, *Phys. Rev.*, VIII., 6, 1916, 674.

A series of exposures were made on successive portions of a plate with the movable lamp set at distances increasing by small increments. Such a series of exposures would then be expected to contain one at which the illumination by the movable lamp would balance that by the fixed lamp as judged by equal blackening of the spectrum bands on the plate.

The average distance for such a balance with the sector at rest, as determined by making settings with increments of half a centimeter, was about 40 cm. It was possible to estimate the true distance to tenths of a centimeter. With the sector running corresponding settings of the movable lamp were made for various openings of the sector, the principal openings being 7.3°, 10° and 19°. The following table gives the results for these openings, the figures being all reduced to a common denominator by dividing the distance of the movable lamp from the slit by the initial distance at which the two beams balance with the sector at rest. The figures are arranged in rows according to the sector opening and in columns according to the individual plates and set ups of the apparatus.

Sector	Distance Observations	Average	Theoretical $\frac{I}{I'} = \frac{S'}{S}$
19°	432, 432, 443, 439, 444, 437, 432, 436, 438, 441, 440, 440	438	435.4
10°	617, 596, 591, 596, 591, 610, 591, 600, 600, 614, 614	602	600
7.3°	712, 690, 695	699	702

The apparatus was taken down and realigned several times in order to eliminate any systematic error. Considerable care was taken to have the spectrograph and runway level, and to have the runway so that the Nernst filament remained in line with the collimator axis. This was accomplished in some instances by halving the distance between the two points at which the spectrum disappeared in shoving the lamp from side to side, and in some instances by placing the filament at one end of the runway in contact with the slit, at the other end making a symmetrical shadow of the collimator

tube on the spectrograph body. The Nernst filament was placed vertically. It was used at such a distance from the slit that at its nearest position to the slit the whole of it was effective in illuminating the plate.

The graduations of the sector opening were compared and corrected with a protractor. The sector wheel ran 120 revolutions per minute, there being two openings in the wheel, the sum of the two being an angular opening equal to that given in the table.

The plates used were half of them Wratten & Wainwright Panchromatic and half Seeds Panchromatic. In one instance a Seeds Process was used with the same results. The plates were given uniform tank development. The exposures were such as to give rather faint images, necessary in order to judge accurately differences in intensity. The exposures were such, however, that with the sector running they were always longer than one minute. A plate would contain a set of exposures for the so-called zero of the experiment, the initial balance distance, and a set of exposures with the sector running, the movable lamp being placed at distances such as to make equivalent sets of exposures. The distances corresponding to the two pairs which matched on such a plate when divided the one by the other gives a quotient which is a figure of the table. With a good setting the two spectral bands balanced throughout if they balanced at all, showing that the proposition is independent of wave length.

As the sector photometer is used for spectrophotometry the two beams fall on a bi-prism in front of the slit with the result that the two beams on the plate are in juxtaposition. Because of the fact that the total reflecting prism used here had been slightly ground on its edges the two bands of the pair in this experiment were .4 mm. apart, which increased somewhat the difficulty of judging equality in blackening. The error in such judgments was probably of the order of 2 per cent. It may have been less than this. The averages for the figures of the table differ as the last two columns show by about a half per cent. from what the figure should be if the diminution in the intensity of the beam due to the sector is photographically equivalent to the diminution due to a proportionate increase in distance.

That this equality exists is certainly a coincidence. Recently Helmick[2] has shown that long exposures produce less blackening than short exposures, the total energy being the same (this being when both the short and long exposure are longer than a certain fixed time). In some rough experiments which I first made I found that the total actual intermittent exposure necessary to produce equal blackening through a 72° sector was about of the order of 12 per cent. longer than for a like continuous exposure, *i. e.*, the sector at rest. The evidence herein contained goes to show that when the beam is dimmed by increasing the distance of its source the exposure must likewise be longer by this same amount. In other words, if B_1, B_2 and B_3 are the blackenings due respectively to a certain beam, to the same beam made intermittent and to a beam of decreased intensity, all of the beams delivering equal total energy through the regulation of the time factor, then B_2 and B_3 are less than B_1 but are equal to each other.

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THE AMERICAN ASSOCIATION OF VARIABLE STAR OBSERVERS

THE seventh annual meeting of the American Association of Variable Star Observers was held at the Harvard Observatory, Cambridge, Mass., on November 23, 1918. More than a score of the members were present and the association became formally incorporated under the laws of Massachusetts. The meeting was, without doubt, the most successful and enjoyable that has yet been held. The reports of the several committees indicated the active interest and aims of the members, and a new committee, under the chairmanship of Professor S. I. Bailey, was appointed to gather together a collection of astronomical slides which could be loaned, under proper supervision, to members who might care to lecture in their vicinity, thus tending to arouse a greater interest in astronomy and particularly variable stars.

[2] P. S. Helmick, *Phys. Rev.*, XI., 5, 1918, 372.